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ON THE CONCEPT AND DIMENSIONS OF HUMAN CAPITAL IN A KNOWLEDGE-BASED ECONOMY CONTEXT

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On the Concept and Dimensions of Human Capital in a Knowledge-Based Economy Context

Abstract

Technological changes along with the globalization of markets are transforming industrial countries into knowledge-driven economies. This shift away from resource-based toward knowledge-based economies has made human capital (and its main component, education) one of the leading public policy themes. Given the policy relevance of human capital in a knowledge-based economy, it is essential that its definition, measurement and specification in economic models capture its key inherent features. This paper discusses the elements of a comprehensive definition of human capital and identifies the fundamental differences between human and physical capital. It shows that the main features of human capital and its differences with physical capital have implications for national income accounting, the classification of government expenditures, and the endogenous growth literature. This analysis highlights the close interactions of policy, human capital and growth in a knowledge-based economy.

Résumé

Les changements technologiques et la globalisation des marchés sont en train de transformer les pays industrialisés en économies axées sur l'information. Cette substitution des technologies d'information aux ressources naturelles comme moteurs de développement économique a fait du capital humain (dont sa principale composante l'éducation) un thème de prélédiction dans les discussions de politiques économiques. Ces discussions deviendront plus pertinentes lorsque le capital humain sera convenablement défini, mesuré et spécifié dans les modèles économiques. Cet essai discute des multiples dimensions du capital humain et identifie les différences fondamentales entre le capital humain et le capital physique. Les auteurs démontrent que le concept et les dimensions propres au capital humain, de même que ses différences avec le capital physique, ont des implications importantes pour la comptabilité nationale, la classification des dépenses gouvernementales et les modèles de croissance endogène. Cette analyse met en évidence l'intéraction étroite entre le capital humain, la politique économique et la croissance pour les économies axées sur les technologies d'information.

I. INTRODUCTION

The importance of human capital as a source of progress and economic growth has long been recognised in the economic literature. Adam Smith (1776) was the first classical economist to include human capital in his definition of capital. He included in the capital stock of a nation the inhabitants' acquired and useful talents, because human skills increase wealth for society as well as for the individual. The concept of human capital was largely forgotten by economists until its re-birth in the early 1960's with the writings of Becker (1962, 1964), Schultz (1961, 1962) and Mincer (1958, 1962, 1974). These economists rekindled this old concept by reaffirming its links with economic growth and by emphasising its importance in explaining earnings differentials.[1] During the same period, the development of neoclassical (Solow-Swan) growth theory failed to provide a framework for incorporating human capital as an engine of growth. Such a framework became available later with the seminal work of Romer (1986) and Lucas (1988) and the emergence of a new endogenous growth literature, which stimulated the interest of economists in the role of human capital as a determinant of economic growth.[2] In some of these models, human capital induces growth by stimulating technological advancement or by enhancing labour productivity. Recent empirical studies of economic growth also suggest that the skills and knowledge of a nation's population are important in determining its economic performance. For instance, a higher stock of human capital can allow a less developed country to converge more

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[1] For an historical survey on the concept of human capital, see Blaug (1976) and Kiker (1966).

[2] For theoretical models of endogenous growth, see Aghion and Howitt (1992), Grossman and Helpman (1991), Rebelo (1991), King and Rebelo (1990), Romer (1990), Lucas (1988), and Romer (1986), among others.

rapidly to the income levels of a developed country through increased absorption of international technologies or capacity of imitation.

The emergence of the endogenous growth literature came about at a time when technological changes are continuously modifying production operations. These changes, along with the globalization of markets, are transforming industrial countries into knowledge-driven economies. This shift away from resource-based toward knowledge-based economies has made human capital one of the leading public policy themes. Given the policy relevance of human capital in a knowledge-based economy, it is essential that its definition, measurement and specification in economic models capture most of its special elements. This paper incorporates various elements of definitions found in the literature into a comprehensive definition of human capital. This definition allows us to identify the fundamental differences between human and physical capital, a comparison that is pertinent for the measurement of human capital and the specifications used for both forms of capital in endogenous growth models.

This analysis highlights the close interactions of policy, human capital and growth in a knowledge-based economy. We show that the main features of human capital and its differences from physical capital have important implications for national accounts, the classification of government expenditures and the evaluation of government policy. We also show how the specification of physical and human capital in endogenous growth models influences the estimated impact of policy on growth and other macroeconomic variables. We thus argue that in order to be able to recommend effective policy programs in a period of transition to a knowledge-based economy, a number of preliminary steps are necessary. First, it is essential to develop a measure of the stock of human capital to calibrate accurately endogenous growth

models and to perform growth accounting studies. Second, the procedures of national and public accounting need to be revised to measure correctly savings and investment, and the effectiveness of government expenditure programs. Third, it is necessary to integrate better human capital theory into endogenous growth models. This would lead to a specific treatment of human capital, rather than a treatment similar to physical capital as is now commonly found in these models.

The arguments that support these recommendations are organized as follows. Section II discusses the major elements of human capital and highlights eight special aspects. Section III identifies the fundamental differences between human and non-human capital with respect to property rights and marketability, accumulation, financing, returns and taxation. Section IV reports on measurement problems associated with human capital. Section V evaluates the treatment of human capital in endogenous growth models. Finally, Section VI provides some concluding remarks.

II. DEFINITION OF HUMAN CAPITAL

Capital is typically defined as produced commodities, which are used in the production of other goods and services.[3] In the neoclassical theory of the firm, capital is one of the factors of production and represents the stock of previous investments made in the economy, which, in turn, required the substitution of current consumption for future consumption. Agents add to the

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[3] Smithson (1982).

stock of capital by reducing current consumption in the expectations of increased consumption in the future.

Human capital is represented by the aggregation of investments in activities, such as education, health, on-the-job training and migration that enhance an individual's productivity in the labour market.[4] More recently, this concept has been extended to include non-market activities.[5] For the purpose of this paper, we define human capital as the aggregation of the innate abilities and the knowledge and skills that individuals acquire and develop throughout their lifetime. The former represents a potential, which is received free of cost by individuals (and society as a whole), while the latter is the actualisation of this potential mostly through individual efforts involving a cost. Both components enhance the productivity of individuals in the production of goods, services and ideas within market as well as non-market environments. The concept of human capital is a complex and multi-faceted one. We suggest that eight specific aspects of the broad definition of human capital outlined above warrant special consideration.

First, this broad definition affirms that human capital comprises an innate and an acquired component. Innate abilities are defined as all physical, intellectual and psychological capacities that individuals possess at the time of birth. They are received as gifts by individuals without any action or choice of their own, and they differ greatly across individuals because of heredity, parental decisions and purely random factors. While innate abilities represent the individual's

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[4] See, for example, Behrman and Taubman (1982), Kiker (1966), Becker (1964), Schultz (1961, 1962).

[5] See, for example, OECD (1996), Jorgenson and Fraumeni (1994), Schultz (1994), and Rosenzweig and Schultz (1985).

potential for human capital accumulation, human capital also includes knowledge and skills, which help actualise this potential. These skills are acquired over one's lifetime through inter-generational transfers of knowledge, personal contacts, work experience, on-the-job-training, education and socialisation.

Second, human capital is a non-tradable good. Whether innate or acquired, skills and knowledge are embodied into human beings. As long as human beings remain non-tradable goods (no slavery), there exists no market that would permit the exchange of human capital assets.

Third, individuals do not always control the channels and pace by which they acquire human capital. When young, they cannot make rational decisions about their needs for human capital, nor can they assess the potential of their innate abilities. Consequently, during the first years of life, human capital decisions are not made by its owners, but by their parents, teachers, governments, and by society as a whole through its educational and social institutions. As individuals become able to make independent decisions, they will internalise the decision process on human capital investments. However, since the owners' ability to invest further in human capital depends on past investments and on the social environment, the influence of their peers and of the institutional context in which they live continually shapes their acquisition of human capital, both in type and amount.

Fourth, human capital can be acquired either formally or informally. Formal acquisition is generally done through established institutions and programs, where knowledge and skills are transmitted in educational environments. Human capital can also be acquired informally,

through a variety of social organisations, personal contacts, work experience (learning by doing), and through self-teaching.

Fifth, human capital has qualitative as well as quantitative aspects. Although one can easily quantify an individual's total years of schooling or daily caloric intake, it cannot be assumed that human capital investments are qualitatively homogeneous. For example, individuals who obtain a university degree from Harvard University may acquire a better formation than those who graduate from less renowned universities.

Sixth, human capital can be either general or specific. Knowledge and abilities are said to be general if it is possible to use them in a variety of activities and if they are easily transferable from one employer to another without any significant loss of value. Conversely, human capital is specific if it can only be used in a limited number of activities and if the dissolution of employment relationships between workers and firms represents considerable losses of value for that can only be regained through costly investments.

Seventh, the stock of knowledge and abilities embodied in every human being may not always be fully utilised. This gap may arise from a mismatch between acquired skills and those demanded by the labour market, from economic fluctuations, from labour market distortions or from individuals' conscious or unconscious decisions not to use and exploit their full potential.

Finally, the definition of human capital also contains the notion of external effects. These spillovers take into account the influence that individuals have on the productivity of others and of physical capital, as well as the fact that individuals will be more productive, for any given level of skills, in an environment containing a high level of human capital. This facet of human

capital highlights the determinant role that highly concentrated human capital centres, such as universities, cities, research centres and agglomerations of high technology firms (e.g. Silicon Valley) have in the development and advancement of knowledge, technology and growth (Jacobs (1984)). Thus, investments in human capital vary in quality according to the innate abilities of each individual, the stock of human capital present in the economy, teachers' skills and education, the availability of financial resources to the individual and society, and the means by which knowledge and abilities are transmitted.

III. COMPARISON BETWEEN HUMAN AND PHYSICAL CAPITAL

Human capital is frequently treated in economics in a manner similar to physical capital. This section highlights the differences between human and physical capital that are relevant to public policy in knowledge-based economies. Human and physical capital differ with respect to property rights and marketability, accumulation, returns, financing, and taxation.

A. Property Rights and Marketability

Physical capital is tangible; something that can easily be seen or touched. It includes machinery, factories, plants, patented processes, raw materials, inventories held by producers or traders and means of transportation and communication. Furthermore, physical capital can easily be sold and transferred from one owner to another. As noted earlier human capital is inseparable from the human being and its ownership is restricted to the individual in whom it is embodied. Unlike physical capital, the stock of human capital is not marketable: only the services that emanate from this stock are market goods.

B. Accumulation

The accumulation of capital in a given period, regardless of its forms, can be defined as the difference between the production of new capital and the depreciation of its existing stock. However, the processes by which human and non-human capital are accumulated differ with respect to decision making, depreciation rates and technology used to produce the two forms of capital.

Decision Process. The decision process in the production and accumulation of human and non-human capital involves decisions under uncertainty by individuals and firms. While the decision about physical capital is typically made by investors or managers, the production of human capital involves decisions by different agents over an individual's lifetime, including parents, educators and peers. This interdependence in the human capital decision results from the fact that every investment in human capital builds upon the existing stock. If an individual's abilities were not developed at a young age, then he/she would confront limited opportunities for human capital accumulation during adulthood.

Accumulation of Capital. The accumulation of human and physical capital exhibits important similarities: for both it requires time and involves foregoing current consumption for an increase in expected future production and consumption. The accumulation of human capital, however, possesses a social aspect that is much less present in the production of physical capital. Indeed, human capital is developed and accumulated through the interactions of individuals and ideas, thereby making it a social activity (Lucas (1988)). This inherent feature of human capital implies that the process by which it is produced and accumulated is more labour-intensive than that for

physical capital. Furthermore, since human capital is formed by the interactions of human beings, it is subject to spillovers and externalities, which have the potential to alter drastically the learning and accumulation processes. This social dimension of human capital has important implications for public policy.

Human and physical capital also differ in terms of *mobility*. Since the stock of human capital is non-tradable, its mobility depends on the owner's capacity to move and adapt to change, as well as on regulations over domestic and international labour movements. For physical capital, its marketable nature as well as increased globalization and industry restructuring have increased its mobility. These differences have led to some specialisation of inputs within the economy. Non-human capital tends to be concentrated in goods and services that are more tradable, such as manufacturing goods. Human capital is used more in industries, such as the public sector and the service industries, which trade less on world markets. Thus, the process by which society acquires human and physical capital differs with respect to their factor intensity, their mobility and their specialisation.

Depreciation. Time depreciates human as well as physical capital. The latter also depreciates when it is either consumed or used up. Knowledge, abilities, and technology embedded in both types of capital become obsolete when new and improved ideas and technology become available. Human capital also deteriorates when it is idle, since inactivity impairs the skills that individuals have acquired throughout their lives. This process can be partly reversed, however, when human capital is again put to use, a feature, which highlights the endogenous aspect of human capital depreciation. While a component of human capital depreciation is directly related to external shocks, ageing, and involuntary unemployment, another component results from an

individual's conscious decision about the use of his/her knowledge and skills in a productive process. Physical capital depreciation may also have an endogenous component determined by the owner's conscious decision about the utilisation of a particular machine, but its relative importance is negligible given the existence of markets for used equipment.

From the investors' perspective, human capital depreciates precipitously at the time of retirement and is reduced to zero at the time of death. However, from society's perspective, the death of individuals who had invested in human capital does not imply a total loss of that capital, as part of their knowledge would have been transmitted to other generations through personal contacts and the production of goods, services and ideas prior to their death. This feature does not apply to non-human capital since it is always possible to sell and transfer physical capital assets from one person to another. A sum invested in human capital ceases to yield a return after the investor's death, at the latest.

C. Financing

Lenders are more willing to lend for physical than for human capital accumulation because the former is marketable and constitutes a better type of collateral. Physical capital can easily be seized, sold, jointly owned and transferred by sale or by inheritance, while human capital is intangible and indissociable from its owner. This makes private financing for the acquisition of human capital harder to obtain. Market failures in the private financing of human capital combined with liquidity constraints resulting from income inequalities and a lower propensity to finance human capital investments would yield a suboptimal level of human capital. To alleviate

these liquidity constraints and the potential inefficiencies resulting from market failures, governments have established programs, which partly subsidise the financing of investments in human capital. For example, governments finance investments in education through lower tuition fees, loans and scholarships.

D. Returns

Investments in physical or human capital are made in order to produce positive rates of returns. While investments in physical capital generate only pecuniary returns, human capital investments also generate non-pecuniary returns. It has been argued that both the stock (Becker (1965), Heckman (1976) and Rebelo (1991)) and the flow of human capital (Lazear (1977)) can be an argument in utility and production functions. Thus, it is difficult to distinguish the consumption motive from the productive motive of human capital formation, a distinction which has important implications for education policy.

The returns to human and physical capital tend to behave differently. When individuals invest in physical capital, they are return-takers, that is, the owners accept the returns dictated by the market and cannot influence them. Since there are no markets for the stock of human capital, investors in human capital become return-makers as the amount, the quality and the maintenance of their human capital stock will dictate what the market will be willing to offer for their services. Thus, returns to investments in human capital are more endogenous than returns to non-human capital investments, thereby increasing its variability across investors.

E. Taxation

The tax treatment of human and physical capital can vary considerably across jurisdictions. We concentrate our attention on the current tax treatment of human and physical capital by the Canadian federal-provincial tax systems.

Since physical capital is produced as part of a business activity, all expenses incurred in its joint production-accumulation stages are deductible in calculating taxable income, thus reducing the tax otherwise payable. Moreover, physical capital is generally free of sales taxation and even the inputs used in the production of physical capital are largely exempt from sales taxes. Investments in physical capital may benefit from public subsidies, loans and loan guarantees. When physical capital is used for production, all expenses related to its operation and maintenance are deductible. Firms can also deduct an amount based on the depreciation of the asset. However, the returns to physical capital may, in some cases, attract taxes at both the corporate and personal level.

The situation is different for human capital. Since human capital is necessarily embodied in human beings, its accumulation requires the steady addition of new children by each successive generation. Although procreation decisions by parents are not usually made for the purpose of increasing the supply of potential human capital, the fiscal system does provide benefits to the generations of new carriers of human capital. In Canada, health-care expenses associated with gestation and birth are provided free of charges (but are financed through general taxation) and some financial support is offered during a specified period prior to and following childbirth. During infancy, additional benefits for low and middle-income families are offered through the

child tax credit and through the tax deduction for child-care expenses. The child and adolescence stages receive fiscal benefits through the provision of almost free compulsory education for those attending public schools. However, no tax deductions are available for any living expenses or any expenses ancillary to primary and secondary education. The only tax benefit is the non-taxation of basic groceries under federal and provincial sale taxes and the non-taxation of clothing, footwear and educational materials in some provinces.

The voluntary acquisition of human capital (e.g. post-secondary education) by an agent receives some tax-related benefits. The foregone salary, which is a large portion of the total cost of a voluntary investment in post-secondary education, is not taxed in Canada, as in most countries. Second, students in post-secondary institutions and other approved institutions of learning can claim a credit against the amount of tuition paid. This credit equals on average 25% of the tuition paid (combined federal-provincial benefits). Moreover, since this credit is non-refundable and can be transferred to a supporting parent, it provides a benefit only to the extent that there is some tax liability to offset. Third, students can claim a non-refundable credit of $100 per month of full time enrolment. All other costs of acquiring human capital - such as food, clothing, shelter, books and other supplies - are not deductible in computing income taxes. Finally, students can be eligible for publicly funded scholarships and loans.

IV. MEASUREMENT PROBLEMS OF HUMAN CAPITAL

As human capital is increasingly recognised by economists and policy makers as a key asset in modern knowledge-based economies, it is crucial to measure its stock and contribution to

economic growth accurately. However, the measurement of the contribution of human capital to economic growth is impeded by the inability of the national and public accounts to measure correctly investments and savings, and classify government expenditures within the context of a knowledge-based economy. Jorgenson and Fraumeni (1994) show that, between 1948 and 1984 in the United States, investment in human capital was almost three times the magnitude of investment in physical capital and that during the same period, the value of human capital exceeded the value of physical capital by more than nine times. Thus, the exclusion of human capital in national and public accounts greatly underestimates the true levels of investment and wealth in an economy. Moreover, recent empirical studies of growth have attempted to assess the role of human capital as a determinant of long-term economic performance using measures of human capital based on, among other things, school enrolment rates (Barro (1991)), literacy rates (Romer (1989)), and educational attainment (Koman and Marin (1997)). These measures are subject to considerable data limitations and only capture certain aspects of human capital.

A. Shortcomings of National and Public Accounts

National Accounts, Savings and Investment. National accounts were developed for the purpose of recording the value of production, income and expenditures during a particular period of time. While these accounts have evolved through time into important yardsticks to gauge the effectiveness of economic policy, their usefulness for the analysis of savings and investment is undermined by their neglect of human capital. In the national accounts, investment includes business expenditures on long-lived assets - such as buildings, machinery and equipment - personal expenditures on housing and government spending on durable investments.

Expenditures on human capital are often treated as consumption. For example, the construction by a firm of a club house on a golf course is classified as investment, while its spending on training is not. In countries devoting increasing quantities of resources to education and training to face the knowledge-based environment, the national accounts would record a decline in the investment-GDP ratio, thus providing misleading information about the country's investment effort.

Similarly, national savings is defined as the difference between the income received by the business, personal and government sectors minus the amount classified as consumption. Since consumption includes expenditures, such as those for education and training, which, as components of human capital, should be classified as investment, the national accounts underestimate the savings rate as well as the rate of investment. For example, income used to purchase foreign equities is treated as personal savings, while the same amount spent on acquiring additional skills is classified as consumption. The former adds nothing to the domestic stock of capital, while the latter increases it.

Estimates of a more general savings rate for the U.S. over the period from 1929 to 1993, including the components associated with human capital, were prepared by Nordhaus (1996). He shows that the "genuine" savings rate is a least three times the "conventional" rate. Moreover, during the past twenty years, the conventional savings rate fell sharply, while the genuine rate remained stable. According to Nordhaus (1996, p. 48), "Our tools for measuring savings are stone-age definitions in the information age".

Public Accounts and Government Expenditures. The shortcomings in the measurement of savings and investment are also considerable in the case of various types of public accounts.

These accounts were developed primarily for the purpose of recording government income and outlays, and although some attempts have been made to provide classifications incorporating economic interpretations, they offer no information on the human capital aspects of government policies. With respect to investment, the definition of the national accounts is used and it is limited to the purchase of fixed assets - such as buildings, waterworks, sewage, machinery and equipment - except when purchased by the armed forces. Yet, the largest share of government purchases is for programs that build up human capital (education) and support its maintenance (health care). By treating the purchase of machines as investment and the acquisition of knowledge and skills as consumption, the existing accounts' structure does not allow policy makers to assess accurately the impact of human capital on growth. For example, the construction of a publicly owned parking lot is recorded as a capital expenditure, while additional spending on teaching is treated as current consumption. Yet, the former adds little to potential economic growth, while the latter is likely to increase it by improving the production of human capital.

The misclassification of government expenditures with respect to human capital - especially those for education and manpower purposes - is equally important, though not so obvious, in the case of transfer payments. At a general level one may note, for example, that in the Canadian national accounts, scholarships and grants to universities are treated as government transfers to persons and placed on equal footing with Guaranteed Income Supplement (GIS) benefits. Yet, the latter supports consumption by the elderly, while the former adds to the nation's stock of knowledge and its rate of economic growth. Moreover, some of the transfer payments, which are classified as government-aided consumption, may be in part investments in

human capital. For example, financial assistance to social institutions, which help individuals in need, may facilitate the accumulation of human capital. When viewed as consumption, these expenditures are considered to be unproductive and behaviourally distortive.

B. Measuring Human Capital

In recent years, several researchers have developed measures of the stock of human capital to facilitate empirical studies on the role of human capital for cross-country growth comparisons.[6] These measures of human capital are compiled to cover broad samples of countries/states, thereby emphasising quantity over quality. Focusing on the broadest sample possible has led to the development of measures of human capital that are unable to capture some of the key dimensions of education, yet alone of human capital.[7] In addition, these measures are subject to considerable data limitations. While censuses are the best source of educational data, they are generally performed every five or ten years and, in some countries, are not performed regularly. Researchers typically use enrolment or educational attainment data in a perpetual inventory framework to fill inter-censal years, which may not be fully satisfactory.

In Canada, few attempts have been made to estimate the stock of human capital. Macklem (1997) estimated human wealth as the present value of aggregate labour income net of government expenditures, while Beach, Boadway and Bruce (1988) produced a human capital

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[6] See, for example, Koman and Marin (1997), Barro and Lee (1996), Barro (1991), Mulligan and Sala-i-Martin (1994, 1995), Nehru et *al.* (1995) and Psacharopoulos and Arriagada (1992).

[7] For a survey of measures of human capital and their limitations, see Laroche and Mérette (1997).

wealth series from 1964 to 1981 by estimating the discounted present value of real after-tax per capita earnings over individuals' lifetime. While these measures are useful tools to assess human and non-human wealth, estimates of Canada's *accumulated human capital* stock are needed to specify accurately endogenous growth models and perform growth accounting studies. Further work is thus required to ensure the collection of relevant educational and other human capital data, and the development of measures of the stock of human capital for Canada and its provinces.

IV. MODELLING HUMAN CAPITAL

Human and physical capital are often treated similarly in endogenous growth models. In many cases, the accumulation processes, the production functions, the factors of production, the input shares and elasticities of substitution, as well as the depreciation rates of human capital and non-human capital are specified similarly. Even the taxation of the factors used in the production of both types of capital is often assumed to be identical.[8] We have argued in Section III that human capital differs from physical capital in many dimensions. We show in this section how the specification of physical and human capital in endogenous growth models influences the estimated impact of policy on growth and other macroeconomic variables. To do so, we give three examples where a specific rather than a similar treatment of physical and human capital leads to different conclusions in endogenous growth models.

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[8] See, for example, Mulligan and Sala-i-Martin (1993), Rebelo (1991), King and Rebelo (1990).

A. Technology and Framework

An important approach in the endogenous growth literature assumes that growth is generated by capital accumulation activities. For instance, there exists a literature on the effect of taxation on growth using a two-sector endogenous growth model[9], where growth is generated by the accumulation of physical capital (final goods sector) and human capital (education sector). It has been shown (Stokey and Rebelo (1995)) that the technology specifications used for the production functions of physical and human capital in these models have an impact on the magnitude of the growth effects of changes in the tax rates applied to factor incomes. The role played by technology specifications is related to the extent to which human capital differs from physical capital. In a two-sector model, a new tax policy will generate intersectoral and intertemporal reallocations. The greater the intertemporal (current versus future consumption) reallocation is relative to the intersectoral (final goods versus education sector) reallocation, the higher will be the growth effect. When human and physical capital technologies are specified symmetrically, that is, with the same inputs and elasticity of substitution, the intertemporal effect dominates and a change in the income tax rate has qualitatively similar effects on both accumulating activities (see Rebelo (1991) and King and Rebelo (1990)). It modifies the rate of return on investment activities and leads to a permanent and significant change in the rate of growth. On the other hand, when human and physical production functions differs, the intersectoral reallocation and sector-specific intertemporal substitution effects become more important. The new tax policy generates more intersectoral than intertemporal reallocation,

[9] See, for example, Devereux and Love (1994), Jones, Manuelli and Rossi (1993), King and Rebelo (1990), and Lucas (1990).

which weakens the impact on growth.[10] Moreover, Mérette (1997) shows that the growth effects of income taxation are often very different in an overlapping generations framework from those obtained in a Ramsey framework. The main reason for this is that the overlapping generations framework captures the life-cycle aspects of investment decisions. These life-cycle aspects are crucial for human capital given its non-tradable nature.

B. Externalities

Human capital accumulation is a social activity: human capital is accumulated through the interactions of ideas and individuals in a way that has no counterpart in the accumulation of physical capital. Only a few endogenous growth models have investigated the effect of externalities from human capital accumulation on growth. In Lucas' (1988) first model, technological externalities arising from human capital production generate output-level effects, but do not change the long-run equilibrium growth rate. Eicher (1996), however, builds upon Grossman and Helpman's (1991) work and proposes a model in which the production of human capital not only forms skilled workers, but also generates technological change, and hence growth. Acemoglu (1996) proposes a microfoundation for social increasing returns in human capital accumulation. His underlying mechanism is a pecuniary externality due to the interaction of *ex ante* investments and costly bilateral search in the labour market. In his framework, returns to human capital are increasing in the average human capital of the workforce, even in the absence of technological externalities. Assuming externalities in the human capital accumulation

[10] See Laroche, Mérette and Ruggeri (1997) for a more technical development.

activity may thus have strong implications for policy experiments within endogenous growth models.

C. Financing

The endogenous growth literature typically specifies two costs associated with individuals' human capital investment. These costs are foregone wages by students during the time spent in school (see, for example, Lucas (1988), Grossman and Helpman (1991, chapter 5.2)) and foregone consumption (tuition) (see, for example, Nerlove *et al.* (1993)). It can be shown that the way human capital investment is financed within a model can directly influence the estimated impact of public policy on growth. For instance, Laroche, Mérette and Ruggeri (1997) use a finite lifetime framework, where human capital is embodied and no deductions are allowed for interest and human capital depreciation. In such a framework, the imposition of an income tax introduces a distortion against human capital accumulation when human capital is financed through foregone consumption, and a distortion in favour of human capital when it is financed through foregone wages.

VI. CONCLUSION

The pivotal role played by human capital in the process of economic growth in knowledge-based economies is increasingly recognised by academics and policy makers. Yet, neither economic accounts nor endogenous growth models capture fully the specific elements of human capital. The former tend to treat spending on human capital as consumption, while the latter tend to

model human capital as if it were physical capital. The result is misleading information on the relevance of human capital and possibly inappropriate policy advice.

This paper suggests that in knowledge-based economies, a major shift in the way we look at human capital is necessary. For example, national income accounts and public sector accounts developed in the early post-war period, and used worldwide ever since, are not designed to capture fully the size and contribution of human capital. As has already been advocated by Jorgenson and Fraumeni (1994) and Nordhaus (1996), among others, a better understanding of the role of human capital in modern economies is predicated on the development of adequate measurement instruments. An obvious starting point would be to develop accurate measures of human capital stocks. In the same vein, it would be useful to distinguish expenditures on public consumption from expenditures on the acquisition and maintenance of human capital. Finally, endogenous growth models must be specified in ways that address the fundamental conceptual differences between human and physical capital.

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